Diet of the endemic Malagasy day gecko *Phelsuma modesta leiogaster* Mertens, 1970 in an urban environment

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Abstract. The day gecko genus *Phelsuma* provides an ideal group in which to investigate the behavioural adaptations that permit survival in urban ecosystems, because it spans the spectrum of degradation tolerance from obligate forest specialists to human commensals. We opportunistically recorded foraging observations of *Phelsuma modesta leiogaster* in a house and garden in urban Toliara, southwest Madagascar, and found the diet to consist principally of natural and artificial sources of sugar (including fruits, honey, sugar, syrups and chocolate), with only 2% of foraging observations consisting of invertebrates. Many *Phelsuma* species consume fruit, pollen or nectar in their diets, and we suggest that the specialisation on sugary foods may permit some species to adapt to urban environments where the availability of such food sources may be artificially high.

Keywords: Adaptation; Anthropogenic environment; Degradation tolerance; Madagascar; Urban ecology

Introduction

The day geckos (genus *Phelsuma*) are a radiation of over 40 species of medium-sized to large arboreal, diurnal geckos distributed throughout Madagascar and the islands of the Western Indian Ocean, as well as coastal areas of East Africa (Harmon et al., 2008; Rocha et al., 2010). They provide an ideal group in which to investigate the behavioural mechanisms of habitat selectivity because members of the genus span the spectrum of degradation tolerance from obligate forest specialists such as *P. flavigularis*, *P. guimbeaui* and *P. ornata* (Glaw and Vences, 2007; Bungard et al., 2014) to strict human commensals rarely if ever recorded in forests, such as *P. modesta* (Glaw and Vences, 2007). Many *Phelsuma* species may be common in urban environments but also occur in primary or degraded forests (e.g. *P. abbotti*, *P. dubia*, *P. hielscheri*, *P. laticauda*, *P. lineata*, *P. madagascariensis*, *P. mutabilis* and *P. quadriocellata* (Glaw and Vences, 2007; Gardner and Jasper, 2009; pers. obs.). However, little is known about the diets of these species or the mechanisms that allow them to adapt to such anthropogenic environments. Here we report observations of the diet of *P. modesta leiogaster* from an urban environment in Madagascar to contribute to filling this knowledge gap.

Methods

From 22nd March 2014 to 11th April 2014, and again from 13th October 2014 to 3rd November 2014, we recorded all foraging and drinking observations of *P. m. leiogaster* within a house and garden in urban Toliara, southwest Madagascar (23°21.00'S, 043°40.80'E). The house was a single-story, concrete walled structure surrounded on two sides by well-vegetated gardens planted with a range of widely-cultivated trees (including papaya, banana, oranges, dates, guava and neem (*Azadirachta indica*)), as well as locally-endemic trees (*Delonix* spp., *Euphorbia* spp., *Adansonia* spp.) and succulents (*Aloe* spp., *Kalanchoe* spp.). At least 17 reptile species occur in Toliara including seven species of gecko that have been recorded on the property (Gardner and Jasper, 2009; Gardner et al., 2015), although only *P. m. leiogaster*, the introduced and nocturnal *Hemidactylus frenatus* and the
nocturnal, ground-dwelling *Paroedura picta* regularly occur within the house. We recorded all opportunistic observations of *P. m. leiogaster* foraging and drinking within the house and garden as we carried out other tasks; observations were thus concentrated in areas where we spent the most time during daylight hours, i.e. our office, the kitchen, and the bathroom. We did not control either for survey effort nor the distribution of available food resources across space or time.

**Results**

We made 49 observations of foraging or drinking by *P. m. leiogaster*, of which 20 % consisted of drinking water (from buckets, the walls of a shower and drinking vessels). Of the remaining foraging observations 2.6 % concerned invertebrates (a single, failed attempt to capture a cockroach), 15.4 % involved honey, 28.6 % involved fruits and vegetables (including pineapple, pineapple juice, bananas, grated carrot, raisins and dates), and almost half (46.2 %) involved artificial sources of sugar (Fig. 1). The latter category included a diverse range of items including flavoured syrups (mint and blackcurrant flavours), refined white sugar, unrefined brown sugar, chocolate, mint-flavoured sweets, sugary coconut macaroons (a baked confection), custard pudding and sweetened milk left over from breakfast cereals (Fig. 2). The species was also sometimes active at night in well lit places, suggesting that it may be predating nocturnal insects attracted to the lights: we never reported such predation attempts during data collection, though we have observed it at other times. We did not make any foraging observation outside the house and only rarely observed the species in the garden.

**Figure 1.** Proportion of foraging and drinking observations of *Phelsuma modesta leiogaster* from a house in urban Toliara, southwest Madagascar, divided by type of food/water. ‘Fruits’ included pineapple, pineapple juice, bananas, grated carrot, raisins and dates, ‘Artificial sugars’ comprised flavoured syrups (mint and blackcurrant flavours), refined white sugar, unrefined brown sugar, chocolate, mint-flavoured sweets, sugary coconut confections, custard pudding and sweetened milk.

**Figure 2.** Adult female *Phelsuma modesta leiogaster* licking honey from a kitchen surface in an urban house, Toliara, southwest Madagascar. Image: Louise Jasper.
at all, though it sometimes basked on sunlit tree trunks adjacent to the building.

Discussion

Our data should be interpreted with caution because most observations were made in the kitchen and office where we spent most of our time, but where fruits and artificial sugar sources were concentrated: these food types may therefore be over-represented in our sample. However a range of insect and other invertebrate orders were also present in these areas as they were throughout the house (which was never treated with any form of chemical insecticide or repellent), yet day geckos were less frequently encountered in other rooms and we only rarely observed predation attempts on invertebrates (i.e. once during this study).

Our observations suggest that urban P. m. leiogaster populations in Toliara may subsist to a large extent on natural and artificial sources of sugar. Like most geckos worldwide, Phelsuma are thought to be primarily insectivorous (Bauer 2003), however many species include significant amounts of fruit, pollen or nectar in their diets (Murphy and Myers, 1996; Olesen et al., 2002, 2012; Deso et al., 2008; Minnaar et al., 2013; Bégue et al., 2014; Taylor and Gardner, 2014) and several may be the obligate pollinators of endemic plant species in the Mascarenes (Nyhagen et al., 2001; Hansen et al., 2006; Hansen and Müller, 2009). Other species are known to steal pollen from bees (Clémencet et al., 2013) and milk honeydew from planthoppers (Fölling et al., 2001), while some of the largest Phelsuma are known to predate vertebrates including other geckos (Garcia and Vences, 2002; Buckland et al., 2014).

It may be that the dietary and behavioural plasticity of the genus predisposes some species to adapt to novel, anthropogenic environments. For example, the nocturnal activity we observed suggests that P. m. leiogaster may be able to take advantage of artificial light sources to prey on nocturnal invertebrates. In particular, we speculate that the high dependence of many species on natural sugars (from fruit and nectar) may be a key mechanism allowing some members of the genus to colonise urban environments, where there may be high concentrations of natural and artificial sources of sugar. However this mechanism can only provide a partial explanation, since a congenic species, Phelsuma mutabilis, is also abundant in urban Toliara and in the garden of the property where we made our observations. We only rarely recorded P. mutabilis inside the house, and infrequently observed P. m. leiogaster in the garden, suggesting that the two species occupy different niches, exploit different food sources, and have been able to colonise urban environments through different behavioural adaptations. Differences in the behavioural and dietary plasticity of Phelsuma species, and thus their ability to adapt to novel, anthropogenic environments, may be an important determinant of extinction risk as forest environments within their range suffer further degradation and loss.

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References


